

## Chapter 2 Preliminary Design

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### 2.1 Preliminary Studies

#### 2.1.1 *Interdisciplinary Design Studies*

Region may set up an Interdisciplinary Design Team (IDT) to review the various design alternatives for major projects. The IDT is composed of members from Regions, HQ, outside agencies, and consulting firms. The members have different areas of expertise, contribute ideas, and participate in the selection of design alternatives. This work will often culminate in the publication of an Environmental Impact Statement (EIS).

Bridge designers may be asked to participate either as a support resource or as a member of the IDT.

#### 2.1.2 *Value Engineering Studies*

Value Engineering (VE) is a review process and analysis of a design project. The VE team seeks to define the most cost-effective means of satisfying the basic function(s) of the project. Usually a VE study takes place before or during the time that the region is working on the design. Occasionally, a VE study examines a project with a completed PS&E. VE studies are normally required for projects with cost overruns.

The VE team is headed by a facilitator and is composed of members with different areas of expertise from Regions, HQ, outside agencies, and consulting firms. The Team Facilitator will lead the team through the VE process. The team will review Region's project as defined by the project's design personnel. The VE team will determine the basic function(s) that are served by the project, brainstorm all possible alternatives to serve the same function(s), evaluate the alternatives for their effectiveness to meet the project's basic functions, determine costs, and prioritize and recommend alternatives. The VE team will prepare a report and present their findings to the region. The Region is then required to investigate and address the VE team's findings in the final design.

Bridge designers may be asked to participate either as a support resource or as a member of the VE team. VE studies usually take place over a three to five day period.

Engineers participating in VE studies and Cost-Risk Assessment meetings shall call the S&E Engineers and double check all costs when providing cost estimates at VE studies and CRA meetings.

#### 2.1.3 *Preliminary Recommendations for Bridge Rehabilitation Projects*

When the Region starts a bridge rehabilitation project, they will submit a written memo requesting that the Bridge and Structures Office make preliminary project recommendations.

The Bridge and Structures Office will review the as-built plans, load ratings, existing inspection and condition reports prepared by the Bridge Preservation Office (BPO), and schedule a site visit with Region and other stakeholders. Special inspection of certain portions of the structure may be included in the site visit or scheduled later with Region and BPO. The purpose of the inspections is to obtain more detailed information as to the bridge's condition, to obtain dimensions and take photographs of details needed for the project recommendations.

Following the site visit, the next steps are:

- Determine the load capacity of the existing bridge.
- Determine what type of rehabilitation work is needed and time frame required to accomplish the work.
- Determine any special construction staging requirements. Can the bridge be totally shut down for the rehabilitation period? How many lanes will need to be open? Can the work be accomplished during night closures or weekend closures?
- Develop various alternatives and cost estimates for comparison, ranging from “do nothing” to “new replacement”.
- Determine what the remaining life expectancies are for the various rehabilitation alternatives.
- Determine the cost of a new replacement bridge.

**Note:** The FHWA will not participate in funding the bridge rehabilitation project if the rehabilitation costs exceed 50 percent of the cost for a new bridge replacement.

The Bridge and Structures Office will provide Region with a written report with background information. The Region will be given an opportunity to review the draft report and to provide input prior to finalization.

The Bridge Projects Engineer and Specifications & Estimates Engineers provide bridge scoping cost estimates to Regions for their use in determining budgets during Region's project definition phase. The S&E Engineers will check the Bridge Project Engineer's estimate as well as check each other.

#### **2.1.4 Preliminary Recommendations for New Bridge Projects**

The Region will seek assistance from the Bridge and Structures Office when they are preparing a design project requiring new bridges. Similar to the procedures outlined above for rehabilitation projects. The Region will submit a written memo requesting that the bridge office make preliminary project recommendations. The Bridge and Structures Office will provide scope of work, cost estimate(s), and a summary of the preferred alternatives with recommendations. Face to face meetings with the Region project staff are recommended prior to sending a written memo.

The Bridge Projects Engineer and Specifications & Estimates Engineers provide bridge scoping cost estimates to Regions for their use in determining budgets during Region's project definition phase. The S&E Engineers will check the Bridge Project Engineer's estimate as well as check each other.

#### **2.1.5 Type, Size, and Location (TS&L) Reports**

The Federal Highway Administration (FHWA) requires that major or unusual bridges must have a Type, Size, and Location (TS&L) report prepared. The report will describe the project, proposed structure(s), cost estimates, other design alternatives considered, and recommendations. The report provides justification for the selection of the preferred alternative. Approval by FHWA of the TS&L study is the basis for advancing the project to the design stage.

The FHWA should be contacted as early as possible in the Project Development stage because the FHWA requires a TS&L study for tunnels, movable bridges, unusual structures, and major structures. Smaller bridges that are unusual or bridge projects for Local Agencies may also require a TS&L study. Other projects, such as long viaducts, may not. Check with the Bridge Projects Engineer to see if a TS&L report is necessary.

The preparation of the TS&L report is the responsibility of the Bridge and Structures Office. The TS&L cannot be submitted to FHWA until after the environmental documents have been submitted. However, TS&L preparation need not wait for environmental document approval, but may begin as soon as the bridge site data is available. See Chapter 1110 of the WSDOT *Design Manual* for the type of information required for a bridge site data submittal.

#### A. TS&L General

The designer should first review the project history in order to become familiar with the project. The environmental and design reports should be reviewed. The bridge site data should be checked so that additional data, maps, or drawings can be requested. A meeting with Region and a site visit should be arranged after reviewing the history of the project.

The Materials Laboratory Geotechnical Services Branch must be contacted early in the TS&L process in order to have foundation information. Specific recommendations on the foundation type must be included in the TS&L report. The Materials Laboratory Geotechnical Services Branch will submit a detailed foundation report for inclusion as an appendix to the TS&L report.

To determine the preferred structural alternative, the designer should:

1. Develop a list of all feasible alternatives. At this stage, the range of alternatives should be kept wide open. Brainstorming with supervisors and other engineers can provide new and innovative solutions.
2. Eliminate the least desirable alternatives by applying the constraints of the project. Question and document the assumptions of any restrictions and constraints. There should be no more than four alternatives at the end of this step.
3. Perform preliminary design calculations for unusual or unique structural problems to verify that the remaining alternatives are feasible.
4. Compare the advantages, disadvantages, and costs of the remaining alternatives to determine the preferred alternative(s).
5. Visit the project site with the Region, Materials Laboratory Geotechnical Services Branch, and HQ Hydraulics staff.

FHWA expects specific information on scour and backwater elevations for the permanent bridge piers, as well as, for any temporary falsework bents placed in the waterway opening.

After the piers have been located, a memo requesting a Hydraulics Report should be sent to the HQ Hydraulics Unit. The HQ Hydraulics Unit will submit a report for inclusion as an appendix to the TS&L report.

The State Bridge and Structures Architect should be consulted early in the TS&L study period. "Notes to the File" should be made documenting the aesthetic requirements and recommendations of the State Bridge and Structures Architect.

Cost backup data is needed for any costs used in the TS&L study. FHWA expects TS&L costs to be based on estimated quantities. This cost data is to be included in an appendix to the TS&L report. The quantities should be compatible with the S&E Engineer's cost breakdown method. The Specifications & Estimates Engineers will check the designer's estimated costs included in TS&L reports. In the case of consultant prepared TS&L reports, the designer shall have the S&E Engineers check the construction costs.

## B. TS&L Outline

The TS&L report should describe the project, the proposed structure, and give reasons why the bridge type, size, and location were selected.

### 1. Cover, Title Sheet, and Index

These should identify the project, owner, location and the contents of the TS&L.

### 2. Photographs

There should be enough color photographs to provide the look and feel of the bridge site. The prints should be numbered and labeled and the location indicated on a diagram.

### 3. Introduction

The introduction describes the report, references, and other reports used to prepare the TS&L study. The following reports should be listed, if used.

- Design Reports and Supplements
- Environmental Reports
- Architectural Visual Assessment or Corridor Theme Reports
- Hydraulic Report
- Geotechnical Reports

### 4. Project Description

The TS&L report clearly defines the project. A vicinity map should be shown. Care should be taken to describe the project adequately but briefly. The project description summarizes the preferred alternative for the project design.

### 5. Design Criteria

The design criteria identify the AASHTO LRFD Bridge Design Specifications and AASHTO guide specifications that will be used in the bridge design. Sometimes other design criteria or special loadings are used. These criteria should be listed in the TS&L. Some examples in this category might be the temperature loading used for segmental bridges or areas defined as wetlands.

### 6. Structural Studies

The structural studies section documents how the proposed structure Type, Size, and Location were determined. The following considerations should be addressed.

- Aesthetics
- Cost Estimates
- Geometric constraints
- Project staging and Stage Construction Requirements
- Foundations
- Hydraulics
- Feasibility of construction
- Structural constraints
- Maintenance

This section should describe how each of these factors leads to the preferred alternative. Show how each constraint eliminated or supported the preferred alternatives. Here are some examples. “Prestressed concrete girders could not be used because environmental restrictions required that no permanent piers could be placed in the river. This requires a 230-foot clear span.” “Restrictions on falsework placement forced the use of self supporting precast concrete or steel girders.”

7. Executive Summary

The executive summary should be able to “stand alone” as a separate document. The project and structure descriptions should be given. Show the recommended alternative(s) with costs and include a summary of considerations used to select preferred alternatives or to eliminate other alternatives.

8. Drawings

Preliminary plan drawings of the recommended alternative are included in an appendix. The drawings show the plan, elevation, and typical section. For projects where alternative designs are specified as recommended alternatives, preliminary plan drawings for each of the different structure types shall be included. Supplemental drawings showing special features, such as complex piers, are often included to clearly define the project.

C. Reviews and Submittals

While writing the TS&L report, all major decisions should be discussed with the unit supervisor, who can decide if the Bridge Design Engineer needs to be consulted. A peer review meeting with the Bridge Design Engineer should be scheduled at the 50 percent completion stage. If applicable, the FHWA Bridge Engineer should be invited to provide input.

The final report must be reviewed, approved, and the Preliminary Plan drawings signed by the State Bridge and Structures Architect, the Bridge Projects Engineer, the Bridge Design Engineer, and the Bridge and Structures Engineer. The TS&L study is submitted with a cover letter to FHWA signed by the Bridge and Structures Engineer.



## 2.2 Preliminary Plan

The Preliminary Plan preparation stage is the most important phase of bridge design because it is the basis for the final design. The Preliminary Plan should completely define the bridge geometry so the final roadway design by the regions and the structural design by the bridge office can take place with minimal revisions.

During the Region's preparation of the highway design, they also begin work on the bridge site data. Region submits the bridge site data to the Bridge and Structures Office, which initiates the start of the Preliminary Plan stage. Information that must be included as part of the bridge site data submittal is described in Chapter 1110 of the *Design Manual*.

### 2.2.1 Development of the Preliminary Plan

#### A. Responsibilities

In general, the responsibilities of the designer, checker, detailer, and unit supervisor are described in Section 1.2.2, Chapter 1, *Bridge Design Manual*. The Preliminary Plan Design Engineer or the assigned designer is responsible for developing a preliminary plan for the bridge. The preliminary plan must be compatible with the geometric, aesthetic, staging, geotechnical, hydraulic, financial, structural requirements and conditions at the bridge site.

Upon receipt of the bridge site data from the Region, the designer shall review it for completeness and verify that what the project calls for is realistic and structurally feasible. Any omissions or corrections are to be immediately brought to the Region's attention so that revised site data, if required, can be resubmitted to avoid jeopardizing the bridge design schedule.

The Unit Supervisor shall be kept informed of progress on the preliminary plan so that the schedule can be monitored. If problems develop, the Unit Supervisor can request adjustments to the schedule or allocate additional manpower to meet the schedule. The designer must keep the job file up-to-date by documenting all conversations, meetings, requests, questions, and approvals concerning the project. Notes-to-the-designer, and details not shown in the preliminary plan shall be documented in the job file.

The checker shall provide an independent review of the plan, verifying that it is in compliance with the site data as provided by the region and as corrected in the job file. The plan shall be compared against the Preliminary Plan checklist (see Appendix A) to ensure that all necessary information is shown. The checker is to review the plan for consistency with office design practice, detailing practice, and for constructibility.

The preliminary plan shall be drawn using current office CAD equipment and software by the designer or detailer.

#### B. Site Reconnaissance

The site data submitted by the Region will include photographs and a video of the site. Even for minor projects, this may not be enough information for the designer to work from to develop a preliminary plan. For most bridge projects, site visits are necessary.

Site visits with Region project staff and other project stakeholders, such as, Materials Laboratory Geotechnical Services Branch, HQ Hydraulics, and Region Design should be arranged with the knowledge and approval of the Bridge Projects Engineer.



C. Coordination

The designer is responsible for coordinating the design and review process throughout the project. This includes seeking input from various WSDOT units and outside agencies. The designer should consult with Materials Laboratory Geotechnical Services Branch, HQ Hydraulics, Bridge Preservation Office, and Region design and maintenance, and other resources for their input.

D. Consideration of Alternatives

In the process of developing the Preliminary Plan, the designer should brainstorm, develop, and evaluate various design alternatives. See Section 2.2.3 General Factors for Consideration and how they apply to a particular site. See also Section 2.1.5A. Preliminary design calculations shall be done to verify feasibility of girder span and spacing, falsework span capacity, geometry issues, and construction clearances. Generally, the number of alternatives will usually be limited to only a few for most projects. For some smaller projects and most major projects, design alternatives merit development and close evaluation. The job file should contain reasons for considering and rejecting design alternatives. This provides documentation for the preferred alternative.

E. Designer Recommendation

The designer should be able to make a recommendation for the preferred alternative after a thorough analysis of the needs and limitations of the site, studying all information, and developing and evaluating the design alternatives for the project. At this stage, the designer should discuss the recommendation with the Bridge Projects Engineer.

F. Concept Approval

For some projects, the presentation, in “E” above, to the Bridge Projects Engineer will satisfy the need for concept approval. Large complex projects, projects of unique design, or projects where two or more alternatives appear viable, should be presented to the Bridge Design Engineer for his/her concurrence before plan development is completed. For unique or complex projects a presentation to the Region Project Engineer, and Bridge and Structures Office Peer Review Committee may be appropriate.

## **2.2.2 Documentation**

A. Job File

An official job file is created by the Bridge Scheduling Engineer when a memo transmitting site data from the region is received by the Bridge and Structures Office. This job file serves as a depository for all communications and resource information for the job. Scheduling and time estimates are kept in this file, as well as cost estimates, preliminary quantities, and documentation of all approvals. Records of important telephone conversations and copies of E-mails approving decisions are also kept in the job file.

After completing the Preliminary Plan, the job file continues to serve as a depository for useful communications and documentation for all pertinent project related information and decisions during the design process through and including preparation of the Final Bridge PS&E.

B. Bridge Site Data

All Preliminary Plans are developed from site data submitted by the Region. This submittal will consist of a memorandum IDC, and appropriate attachments as specified by Chapter 1110 of the *Design Manual*. When this information is received, it should be reviewed for completeness so that missing or incomplete information can be noted and requested.

C. Request for Preliminary Foundation Data

A request for preliminary foundation data is sent to the Geotechnical Services Branch to solicit any foundation data that is available at the preliminary stage. The Materials Laboratory Geotechnical Services Branch is provided with approximate dimensions for the overall structure length and width, approximate number of intermediate piers (if applicable), and approximate stations for beginning and end of structure on the alignment.

Based on test holes from previous construction in the area, geological maps, and soil surveys. The Materials Laboratory Geotechnical Services Branch responds by memo and a report with an analysis of what foundation conditions are likely to be encountered and what foundation types are best suited for the bridge site.

D. Request for Preliminary Hydraulics Data

A Request for preliminary hydraulics data is sent to the HQ Hydraulics Office to document hydraulic requirements that must be considered in the structure design. The HQ Hydraulics Office is provided a contour plan and other bridge site data.

The Hydraulics Office will send a memo providing the following data: seal vent elevations, normal water, 100-year and 500-year flood elevations and flows (Q), pier configuration, scour depth and minimum footing cover required, ice pressure, minimum waterway channel width, riprap requirements, and minimum clearance required to the 100-year flood elevation.

E. Design Report or Design Summary and Value Engineering Studies

Some bridge construction projects have a Design File Report or Design Summary prepared by the region. This is a document, which includes design considerations and conclusions reached in the development of the project. It defines the scope of work for the project. It serves to document the design standards and applicable deviations for the roadway alignment and geometry. It is also an excellent reference for project history, safety and traffic data, environmental concerns, and other information. If a VE study was done on the bridge, the report will identify alternatives that have been studied and why the recommended alternative was chosen.

F. Other Resources

For some projects, preliminary studies or reports will have been prepared. These resources can provide additional background for the development of the Preliminary Plan.

G. Notes of meetings with Regions and other project stakeholders shall be included in the job file.

### **2.2.3 General Factors for Consideration**

Many factors must be considered in preliminary bridge design. Some of the more common of these are listed in general categories below. These factors will be discussed in appropriate detail in subsequent portions of this manual.

A. Site Requirements

- Topography
- Alignment (tangent, curved, skewed)
- Vertical profile and superelevation
- Highway Class and design speed
- Proposed or existing utilities

- B. Safety
  - Feasibility of falsework (impaired clearance and sight distance, depth requirements, see BDM 2.3.10)
  - Density and speed of traffic
  - Detours or possible elimination of detours by construction staging
  - Sight distance
  - Horizontal clearance to piers
  - Hazards to pedestrians, bicyclists
- C. Economic
  - Funding classification (federal and state funds, state funds only, local developer funds)
  - Funding level
  - Bridge preliminary cost estimate
- D. Structural
  - Limitation on structure depth
  - Requirements for future widening
  - Foundation and groundwater conditions
  - Anticipated settlement
  - Stage construction
  - Falsework limitations
- E. Environmental
  - Site conditions (wetlands, environmentally sensitive areas)
  - EIS requirements
  - Mitigating measures
  - Construction access
- F. Aesthetic
  - General appearance
  - Compatibility with surroundings and adjacent structures
  - Visual exposure and experience for public
- G. Construction
  - Ease of construction
  - Falsework clearances and requirements
  - Erection problems
  - Hauling difficulties and access to site
  - Construction season
  - Time limit for construction
- H. Hydraulic
  - Bridge deck drainage
  - Stream flow conditions and drift
  - Passage of flood debris
  - Scour, effect of pier as an obstruction (shape, width, skew, number of columns)
  - Bank and pier protection
  - Consideration of a culvert as an alternate solution
  - Permit requirements for navigation and stream work limitations

I. Maintenance

Concrete vs. Steel

Expansion joints

Bearings

Deck protective systems

Inspection and Maintenance Access (UBIT clearances) (see Figure 2.3.101)

J. Other

Prior commitments made to other agency officials and individuals of the community

Recommendations resulting from preliminary studies

#### **2.2.4 Permits**

A. Coast Guard

As outlined in Chapter 240 of the *Design Manual*, the Bridge and Structures Office is responsible for coordinating and applying for Coast Guard permits for bridges over waterways. This is handled by the Coast Guard Liaison Engineer in the Bridge Projects Unit of the Bridge and Structures Office.

A determination of whether a bridge requires a permit is known before the bridge site data is received. Generally, tidal-influenced waterways and waterways used for commercial navigation will require Coast Guard permits.

For all waterway crossings, the Coast Guard Liaison Engineer is required to initial the Preliminary Plan as to whether a Coast Guard permit or exemption is required. This box regarding Coast Guard permit status is located in the center left margin of the plan. If a permit is required, the permit target date will also be noted. The reduced print, signed by the Coast Guard Liaison Engineer, shall be placed in the job file.

The work on developing the permit application should be started so that it is ready to be sent to the Coast Guard eight months prior to the project ad date. The Coast Guard Liaison Engineer should be given a copy of the preliminary plan from which to develop the plan sheets, which are part of the permit.

B. Other

All other permits will be the responsibility of the Region. The Bridge and Structures Office may be asked to provide information to the Region to assist them in making applications for these permits.

#### **2.2.5 Preliminary Cost Estimate**

A preliminary cost estimate should be developed when the bridge type, foundation type, deck area and adjacent retaining walls are determined. At the preliminary stage the cost estimate is based on square-foot costs taken from the BDM Chapter 12 and adjusted for structure specifics. Consult with a Specifications and Estimates Engineer. The preliminary cost estimate is based on recent bidding history on similar structures, degree of difficulty of construction, inflation trends, and length of time until Ad Date, and time for completion of construction. It is considered accurate to within 15%, but is should be accurate enough to preclude a surprise increase at the time of the Engineer's estimate, which is based on completed design quantities. The preliminary cost estimate shall be updated frequently as changes are made to the preliminary plan or new data influences the costs.

After a Preliminary Plan has been developed, but before sending to the Bridge Design Engineer for signature, the Preliminary Plan and cost estimate shall be submitted to one of the Bridge Specifications and Estimates Engineers for review and comment for the structures in the Preliminary Plan. The information presented to the S&E Engineer shall include the complete Preliminary Plan and all backup data previously prepared on costs for the structures (such as preliminary quantity calculations, preliminary foundation type selection, etc.). The S&E Engineer will review the Preliminary Plan, prepare, sign, and date a cost estimate summary sheet, and return the package to the designer. When the Preliminary Plan is presented to the Bridge Design Engineer, the submittal shall include the summary sheet prepared by the S&E Engineer. The summary sheet and backup data will then be placed in the job file. Do not send the summary sheet to the Region.

After submittal of the Preliminary Plan to the Region, the Region shall be notified immediately of any increases in the preliminary cost estimate during the structural design.

### **2.2.6 Approvals**

#### **A. State Bridge and Structures Architect/Specialists**

For all preliminary plans, the State Bridge and Structures Architect and appropriate specialists should be aware and involved when the designer is first developing the plan. The State Bridge and Structures Architect and specialists should be given a print of the plan by the designer. This is done prior to checking the preliminary plan. The State Bridge and Structures Architect and specialist will review, approve, sign and date the print. This signed print is placed in the job file. If there are any revisions, which affect the aesthetics of the approved preliminary plan, the State Bridge and Structures Architect should be asked to review and approve, by signature, a print showing the revisions, which change elements of aesthetic significance.

For large, multiple bridge projects, the State Bridge and Structures Architect should be contacted for development of a coordinated architectural concept for the project corridor.

The architectural concept for a project corridor is generally developed in draft form and reviewed with the project stakeholders prior to finalizing. When finalized, it should be signed by the Region Administrator or his/her designee.

In order to achieve superstructure type optimization and detailing consistency, the following guidelines shall be used for the preparation of all future Preliminary Plans:

- Preliminary Plans for all steel bridges and structures shall be reviewed by the Steel Specialist.
- Preliminary Plans for all concrete bridges and structures shall be reviewed by the Concrete Specialist.
- Detailing of all Preliminary Plans shall be reviewed by the Preliminary Plans Detailing Specialist.

These individuals shall signify their approval by signing the preliminary plan in the Architect/Specialist block on the first plan sheet, together with the State Bridge and Structures Architect.

#### **B. Bridge Design**

The Bridge Projects Engineer signs the preliminary plan after it has been checked and approved by the Architect/Specialists. At this point, it is ready for review, approval, and signing by the Bridge Design Engineer and the Bridge and Structures Engineer.

After the Bridge and Structures Engineer has signed the preliminary plan, it is returned to the designer. The designer places the original signed preliminary plan in the job file and enters the names of the signers in the signature block. This preliminary plan will be sent to region for their review and approval.

The transmittal memo includes the preliminary plan and the WSDOT Form 230-038 “Not Included in Bridge Quantities List” and a brief explanation of the preliminary cost estimate. It is addressed to the Region Administrator/Project Development Engineer from the Bridge and Structures Engineer/Bridge Design Engineer. The memo is reviewed by the Bridge Projects Engineer and is initialed by the Bridge Design Engineer.

The following should be included in the cc distribution list with attachments: FHWA Washington Division Bridge Engineer (when project has Federal Funding), Region Project Engineer, Bridge Projects Engineer, Bridge Design Unit Supervisor, State Geotechnical Engineer, HQ Hydraulics Engineer, Bridge Management Engineer (when it is a replacement) Bridge Preservation Engineer, HQ Bridge Construction Engineer, and Region Traffic Engineer (when ITS is required). The Bridge Scheduling Engineer and the Region and HQ Program Management Engineers should receive a copy of the preliminary plan distribution memo without the attachments.

C. Region

Prior to the completion of the preliminary plan, the designer should meet with the Region to discuss the concept, review the list of items to be included in the “Not Included in Bridge Quantities List” and get their input. (This is a list of non-bridge items that appear on the bridge preliminary plan and eventually on the design plans.)

The Region will review the preliminary plan for compliance and agreement with the original site data. They will work to answer any “*Notes to the Region*” that have been listed on the plan. When this review is complete, the Regional Administrator, or his/her designee, will sign the plan. The Region will send back a print of the signed plan with any comments noted in red (additions) and green (deletions) along with responses to the questions raised in the “*Notes to the Region*”.

D. Railroad

When a railroad is involved with a structure on a Preliminary Plan, the HQ RR Liaison Engineer of the Design Office must be involved during the plan preparation process. A copy of the Preliminary Plan is sent to the HQ RR Liaison Engineer, who then sends a copy to the railroad involved for their comments and approval.

The railroad will respond with approval by letter to the HQ RR Liaison Engineer. A copy of this letter is then routed to the Bridge and Structures Office and then placed in the job file.

For design plans prepared within the Bridge and Structures Office, the Unit Supervisor or lead designer will be responsible for coordinating and providing shoring plans for structures adjacent to railroads. It is recommended that the Construction Support Unit design, prepare, stamp, and sign shoring plans. However, the design unit may elect to design, prepare, stamp, and sign shoring plans.

For consultant prepared design plans, the Unit Supervisor or lead reviewer will be responsible for coordinating and having the consultant design shoring plans for structures adjacent to railroads. The Construction Support Unit has design criteria and sample plan details which can be used by the design units and consultants.

A Construction Support engineer is available to attend design project kick-off meetings if there is a need for railroad shoring plans or other constructability issues associated with the project. Regardless of who prepares the bridge plans, all shoring plans should be reviewed by the Construction Support Unit before they are submitted for railroad review and approval at the 50% Final PS&E stage.

For completed shelf projects, the S&E Engineer will contact the Region Project Engineer and inform the Unit Supervisor or lead reviewer on the need for shoring plans for structures adjacent to railroads. If shoring plans are required, the unit supervisor or lead designer may ask the Construction Support Unit to prepare shoring plans.

At the 50% PS&E plan completion stage or sooner if possible, especially for seismic retrofit project, the S&E Engineer will send four (4) copies of the layout, foundation plan, temporary shoring plans, and appropriate special provision section for structures adjacent to railroads to the HQ RR Liaison Engineer, who will submit this package to the appropriate railroad for review and approval. The shoring plans shall show the pressure loading diagram and calculations to expedite the railroad's review and approval.



## 2.3 Preliminary Plan Criteria

### 2.3.1 Highway Crossings

#### A. General

A highway crossing is defined as a grade separation between two intersecting roadways. Naming convention varies slightly between mainline highway crossings and ramp highway crossings, but essentially, all bridges carry one highway, road, or street over the intersecting highway, road, or street.

##### 1. Mainline highway crossings

Names for mainline highway crossings are defined by the route designation or name of state highway, county road, or city street being carried over another highway, road, or street.

For example, a bridge included as part of an interchange involving I-182 and SR 14 and providing for passage of traffic on I-182 under SR 14 would be named SR 14 Over I-182 (followed by the bridge number).

##### 2. Ramp highway crossings

Names for ramp highway crossings are defined by the state highway route numbers being connected, the directions of travel being connected, and the designation or name of the highway, road, or street being bridged.

For example, a bridge in the Hewitt Avenue Interchange connecting traffic from westbound US 2 to northbound I-5 and passing over Everett Street would be named 2W-5N Ramp Over Everett Street (followed by the bridge number). A bridge connecting traffic from northbound I-5 to westbound SR 518 and passing over northbound I-405 and a ramp connecting southbound I-405 to northbound I-5 would be named 5N-518W Over 405N,405S-5N (followed by the bridge number).

#### B. Bridge Width

The bridge roadway channelization (configuration of lanes and shoulders) is provided by the region with the Bridge Site Data. For state highways, the roadway geometrics are controlled by Chapters 430 and 440 of the *Design Manual*. For city and county arterials, the roadway geometrics are controlled by Chapter IV of the *Local Agency Guidelines*.

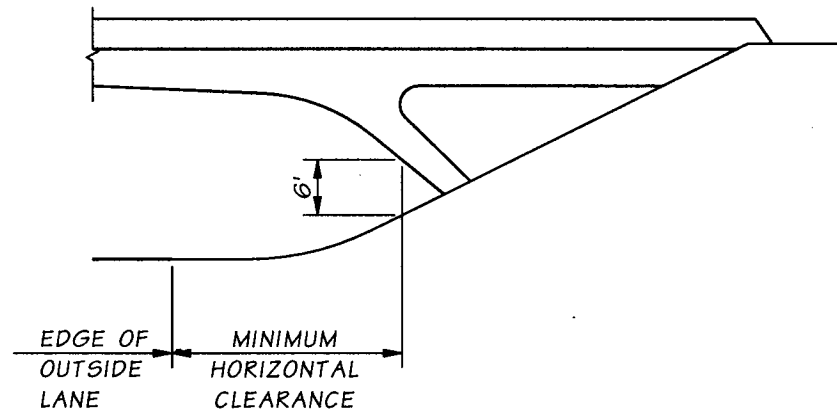
#### C. Horizontal Clearances

Safety dictates that fixed objects be placed as far from the edge of the roadway as is economically feasible. Criteria for minimum horizontal clearances to bridge piers and retaining walls are outlined in the *Design Manual*. Chapter 700 of the *Design Manual* outlines clear zone and recovery area requirements for horizontal clearances without guardrail or barrier being required.

Actual horizontal clearances shall be shown in the plan view of the Preliminary Plan (to the nearest 0.1 foot). Minimum horizontal clearances to inclined columns or wall surfaces should be provided at the roadway surface and for a vertical distance of 6 feet above the edge of pavement. When bridge end slopes fall within the recovery area, the minimum horizontal clearance should be provided for a vertical distance of 6 feet above the fill surface. See Figure 2-6.

Bridge piers and abutments ideally should be placed such that the minimum clearances can be satisfied. However, if for structural or economic reasons, the best span arrangement requires a pier to be within clear zone or recovery area, and then guardrail or barrier can be used to mitigate the hazard.

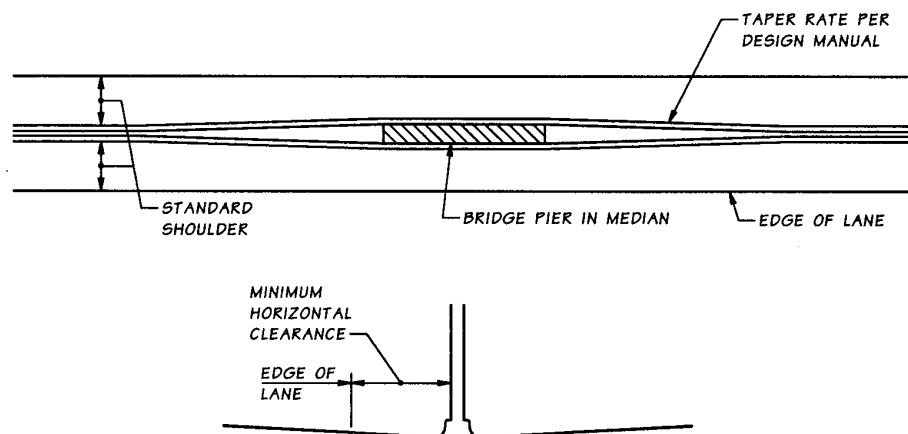
There are instances where it may not be possible to provide the minimum horizontal clearance even with guardrail or barrier. An example would be placement of a bridge pier in a narrow median. The required column size may be such that it would infringe on the shoulder of the roadway. In such cases, the barrier safety shape would be incorporated into the shape of the column. Barrier or guardrail would need to taper into the pier at a flare rate satisfying the criteria in Chapter 710 of the *Design Manual*. See Figure 2-2. The reduced clearance to the pier would need to be approved by the Region. Horizontal clearances, reduced temporarily for construction, are covered in BDM Section 2.3.9.



**Horizontal Clearance to Incline Piers**

**1990**

**Figure 2-1**



**Bridge Pier in Narrow Median**

**1990**

**Figure 2-2**

#### D. Vertical Clearances

The required minimum vertical clearances are established by the functional classification of the highway and the construction classification of the project. For state highways, this is as outlined in Chapters 430, 440, and 1120 of the *Design Manual*. For city and county arterials, this is as outlined in Chapter IV of the Local Agency Guidelines.

Actual minimum vertical clearances are shown on the Preliminary Plan (to the nearest 0.1 foot). The approximate location of the minimum vertical clearance is noted in the upper left margin of the plan. For structures crossing divided highways, minimum vertical clearances for both directions are noted.

## E. End Slopes

The type and rate of end slope used at bridge sites is dependent on several factors. Soil conditions and stability, right of way availability, fill height or depth of cut, roadway alignment and functional classification, and existing site conditions are important.

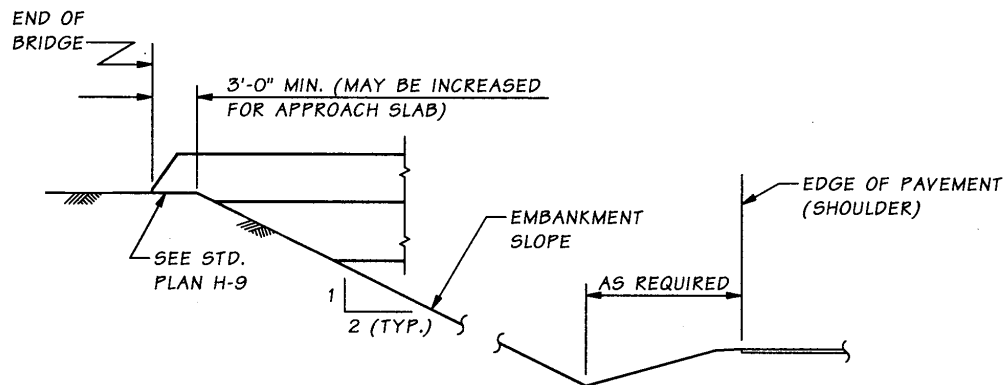
The region should have made a preliminary determination based on these factors during the preparation of the bridge site data. The side slopes noted on the Roadway Section for the roadway should indicate the type and rate of end slope.

The Materials Laboratory Geotechnical Services Branch will recommend the minimum rate of end slope. This should be compared to the rate recommended in the Roadway Section and to existing site conditions (if applicable). The types of end slopes and bridge slope protection are discussed in Chapters 640 and 1120 of the *Design Manual*. Examples of slope protection are shown on Standard Plan D-9.

## F. Determination of Bridge Length

Establishing the location of the end piers for a highway crossing is a function of the profile grade of the overcrossing roadway, the superstructure depth, the minimum vertical and horizontal clearances required for the structure, the profile grade and channelization (including future widening) of the undercrossing roadway, and the type and rate of end slope used.

For the general case of bridges in cut or fill slopes, the control point is where the cut or fill slope plane meets the bottom of roadside ditch or edge of shoulder as applicable. From this point, the fill or cut slope plane is established at the recommended rate up to where the slope plane intersects the grade of the roadway at the shoulder. Following the requirements of Standard Plan H-9, the back of pavement seat, end of wing wall or end of retaining wall can be established at 3 feet behind the slope intersection. See Figure 2-3



**Determination of Bridge Length**

**Figure 2-3**

For the general case of bridges on wall type abutments or “closed” abutments, the controlling factors are the required horizontal clearance and the size of the abutment. This situation would most likely occur in an urban setting or where right of way or span length is limited.

G. Pedestrian Crossings

Pedestrian crossings follow the same format as highway crossings. Geometric criteria for bicycle and pedestrian facilities are established in Chapters 1020 and 1025 of the *Design Manual*. Width and clearances would be as established there and as confirmed by region. Minimum vertical clearance over a roadway is given in Chapter 1025 and 1120 of the *Design Manual*. Unique items to be addressed with pedestrian facilities include ADA requirements, the railing to be used, handrail requirements, overhead enclosure requirements, and profile grade requirements for ramps and stairs.

H. Bridge Redundancy

Design bridges to minimize the risk of catastrophic collapse by using redundant supporting elements (columns and girders).

For substructure design use:

One column minimum for roadways 40 feet wide and under.

Two columns minimum for roadways over 40 feet to 60 feet.

Three columns minimum for roadways over 60 feet.

Collision protection or design for collision loads for piers with one or two columns.

For superstructure design use:

Three girders (webs) minimum for roadways 32 feet and under.

Four girders (webs) minimum for roadways over 32 feet.

See Appendix 2.3-A2 for details.

Note: Any deviation from the above guidelines shall have a written approval by the Bridge Design Engineer.

### **2.3.2 Railroad Crossings**

A. General

A railroad crossing is defined as a grade separation between an intersecting highway and a railroad. Names for railroad crossings are defined either as railroad over state highway or state highway over railroad. For example, a bridge carrying BNSF railroad tracks over I-5 would be named BNSF Over I-5 (followed by the bridge number) A bridge carrying I-90 over Union Pacific railroad tracks would be named I-90 Over UPRR (followed by the bridge number).

Requirements for highway/railway grade separations may involve negotiations with the railroad company concerning clearances, geometrics, utilities, and maintenance roads. The railroad's review and approval will be based on the completed Preliminary Plan.

B. Criteria

The initial Preliminary Plan shall be prepared in accordance with the criteria of this section to apply uniformly to all railroads. Variance from these criteria will be negotiated with the railroad, when necessary, after a Preliminary Plan has been provided for their review.

C. Bridge Width

For highway over railway grade separations the provisions of Section 2.3.1 pertaining to bridge width of highway crossings shall apply. Details for railway over highway grade separations will depend on the specific project and the railroad involved.

D. Horizontal Clearances

For railway over highway grade separations, undercrossings, the provisions of BDM Section 2.3.1 pertaining to horizontal clearances for highway crossings shall apply. However, because of the heavy live loading of railroad spans, it is advantageous to reduce the span lengths as much as possible. For railroad undercrossings skewed to the roadway, piers may be placed up to the outside edge of standard shoulders (or 8 feet minimum) if certain conditions are met (known future roadway width requirements, structural requirements, satisfactory aesthetics, satisfactory sight distance, barrier protection requirements, etc.).

For railroad overcrossings, minimum horizontal clearances are as noted below:

	<b>Railroad Alone</b>
Fill Section	14 feet
Cut Section	16 feet

**Table 2--4**

Horizontal clearance shall be measured from the center of the outside track to the face of pier. When the track is on a curve, the minimum horizontal clearance shall be increased at the rate of 1 1/2 inches for each degree of curvature. An additional 8 feet of clearance for off-track equipment shall only be provided when specifically requested by the railroad.

The actual minimum horizontal clearances shall be shown in the Plan view of the Preliminary Plan (to the nearest 0.01 foot).

E. Crash Walls

Crash walls, when required, shall be designed to conform to the criteria of the *AREMA Manual*. To determine when crash walls are required, consult the following:

Union Pacific Railroad, "Guidelines for Design of Highway Separation Structures over Railroad (Overhead Grade Separation)"

AREMA Manual

WSDOT Railroad Liaison Engineer  
the Railroad

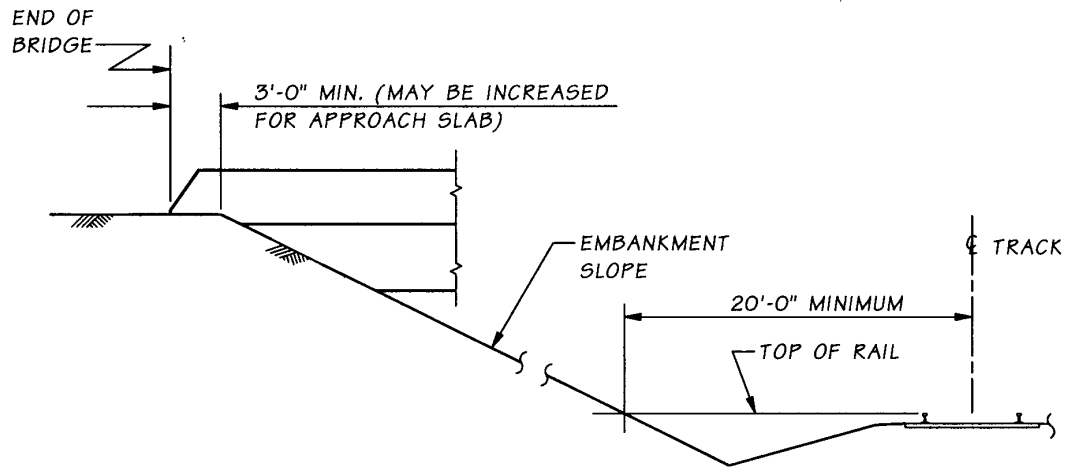
F. Vertical Clearances

For railway over highway grade separations, the provisions of BDM Section 2.3.1 pertaining to vertical clearances of highway crossings shall apply. For highway over railway grade separations, the minimum vertical clearance shall satisfy the requirements of Chapter 1120 of the *Design Manual*.

The actual minimum vertical clearances shall be shown on the Preliminary Plan (to the nearest 0.1 foot). The approximate location of the minimum vertical clearance is noted in the upper left margin of the plan.

G. Determination of Bridge Length

For railway over highway grade separations, the provisions of BDM Section 2.3.1 pertaining to the determination of bridge length shall apply. For highway over railway grade separations, the minimum bridge length shall satisfy the minimum horizontal clearance requirements. The minimum bridge length shall generally satisfy the requirements of Figure 2-5.



**Determination of Bridge Length for for a Highway Over Railway Grade Separation**

**Figure 2-5**

#### H. Special Considerations

For highway over railway grade separations, the top of footings for bridge piers or retaining walls adjacent to railroad tracks shall be 2 feet or more below the elevation of the top of tie and shall not have less than 2 feet of cover from the finished ground. The footing face shall not be closer than 10 feet to the center of the track. Any cofferdams, footings, excavation, etc., encroaching within 10 feet of the center of the track requires the approval of the railroad.

#### I. Construction Openings

For railroad clearances, see Section 1120 of the WSDOT Bridge Design Manual. The minimum horizontal construction opening is 9 feet to either side of the centerline of track. The minimum vertical construction opening is 23 feet 6 inches above the top of rail at 6 feet offset from the centerline of track. Falsework openings shall be checked to verify that enough space is available for falsework beams to span the required horizontal distances and still provide the minimum vertical falsework clearance. Minimum vertical openings of less than 23 feet 6 inches shall be coordinated with the HQ Railroad Liaison Engineer.

### 2.3.3 Water Crossings

#### A. Bridge Width

The provisions of Section 2.3.1 pertaining to bridge width for highway crossings apply here.

#### B. Horizontal Clearances

Water crossings over navigable waters requiring clearance for navigation channels shall satisfy the horizontal clearances required by the Coast Guard. Communication with the Coast Guard will be handled through the Coast Guard Liaison Engineer. For bridges over navigable waters, the centerline of the navigation channel and the horizontal clearances (to the nearest 0.1 foot) to the piers or the pier protection shall be shown on the Plan view of the Preliminary Plan. Pier locations shall be reviewed by the HQ Hydraulics unit.

#### C. Vertical Clearances

Vertical clearances for water crossings must satisfy floodway clearance and, where applicable, navigation clearance.

Bridges over navigable waters must satisfy the vertical clearances required by the Coast Guard. Communication with the Coast Guard will be handled through the Coast Guard Liaison Engineer. The actual minimum vertical clearance (to the nearest 0.1 foot) for the channel span shall be shown on the Preliminary Plan. The approximate location of the minimum vertical clearance shall be noted in the upper left margin of the plan. The clearance shall be shown to the water surface as required by the Coast Guard criteria.

Floodway vertical clearance will need to be discussed with the HQ Hydraulics Office. In accordance with the flood history, nature of the site, character of drift, and other factors, they will determine a minimum vertical clearance for the 100-year flood. The roadway profile and the bridge superstructure depth must accommodate this. The actual minimum vertical clearance to the 100-year flood shall be shown (to the nearest 0.1 foot) on the Preliminary Plan, and the approximate location of the minimum vertical clearance shall be noted in the upper left margin of the plan.

D. End Slopes

The type and rate of end slopes for water crossings is similar to that for highway crossings. Soil conditions and stability, fill height, location of toe of fill, existing channel conditions, flood and scour potential, and environmental concerns are all important.

As with highway crossings, the Region, and Materials Laboratory Geotechnical Services Branch will make preliminary recommendations as to the type and rate of end slope. The HQ Hydraulics Office will also review the Region's recommendation for slope protection.

E. Determination of Bridge Length

Determining the overall length of a water crossing is not as simple and straightforward as for a highway crossing. Floodway requirements and environmental factors have a significant impact on where piers and fill can be placed.

If a water crossing is required to satisfy floodway and environmental concerns, it will be known by the time the Preliminary Plan has been started. Environmental studies and the Design Report prepared by the region will document any restrictions on fill placement, pier arrangement, and overall floodway clearance. The Hydraulics Office will need to review the size, shape, and alignment of all bridge piers in the floodway and the subsequent effect they will have on the base flood elevation. The overall bridge length may need to be increased depending on the span arrangement selected and the change in the flood backwater, or justification will need to be documented.

F. Scour

The HQ Hydraulics Office will indicate the anticipated depth of scour at the bridge piers. They will recommend pier shapes to best streamline flow and reduce the scour forces. They will also recommend measures to protect the piers from scour activity or accumulation of drift (use of deep foundations, minimum cover to top of footing, riprap, pier alignment to stream flow, closure walls between pier columns, etc.).

G. Pier Protection

For bridges over navigable channels, piers adjacent to the channel may require pier protection such as fenders or pile dolphins. The Coast Guard will determine whether pier protection is required. This determination is based on the horizontal clearance provided for the navigation channel and the type of navigation traffic using the channel.



#### H. Construction Access and Time Restrictions

Water crossings will typically have some sort of construction restrictions associated with them. These must be considered during preliminary plan preparation.

The time period that the Contractor will be allowed to do work within the waterway may be restricted by regulations administered by various agencies. Depending on the time limitations, a bridge with fewer piers or faster pier construction may be more advantageous even if more expensive.

Contractor access to the water may also be restricted. Shore areas supporting certain plant species are sometimes classified as wetlands. A work trestle may be necessary in order to work in or gain access through such areas. Work trestles may also be necessary for bridge removal as well as new bridge construction. Work trestle feasibility, location, staging, deck area and approximate number of piles, and estimated cost need to be determined to inform the Region as part of the bridge preliminary plan.

### 2.3.4 Bridge Widening

#### A. Bridge Width

The provisions of BDM Section 2.3.1 pertaining to bridge width for highway crossings shall apply. In most cases, the width to be provided by the widening will be what is called for by the design standards, unless a deviation is approved.

#### B. Traffic Restrictions

Bridge widenings involve traffic restrictions on the widened bridge and, if applicable, on the lanes below the bridge. The bridge site data submitted by the region should contain information regarding temporary lane widths and staging configurations. This information should be checked to be certain that the existing bridge width, and the bridge roadway width during the intermediate construction stages of the bridge are sufficient for the lane widths, shy distances, temporary barriers, and construction room for the contractor. These temporary lane widths and shy distances are noted on the Preliminary Plan. The temporary lane widths and shy distances on the roadway beneath the bridge being widened should also be checked to ensure adequate clearance is available for any substructure construction.

#### C. Construction Sequence

A construction sequence shall be developed using the traffic restriction data in the bridge site data. The construction sequence shall take into account the necessary steps for construction of the bridge widening including both the substructure and superstructure. Placement of equipment is critical because of limited access and working space limitations. Space is required for cranes to construct shafts and erect the girders. Consult the Construction Support Unit for crane information, such as: boom angle, capacities, working loads, working radius, and crane footprint. Construction work off of and adjacent to the structure and the requirements of traffic flow on and below the structure shall be taken into account. Generally, cranes are not allowed to lift loads while supported from the existing structure. Checks shall be made to be certain that girder spacing, closure pours, and removal work are all compatible with the traffic arrangements.

Projects with several bridges being widened at the same time should have sequencing that is compatible with the Region's traffic plans during construction and that allow the Contractor room to work. It is important to meet with the Region project staff to assure that the construction staging and channelization of traffic during construction is feasible and minimizes impact to the traveling public.

### **2.3.5 Detour Structures**

#### **A. Bridge Width**

The lane widths, shy distances, and overall roadway widths for detour structures are determined by the Region. Review and approval of detour roadway widths is done by the HQ Traffic Office.

#### **B. Live Load**

All detour structures shall be designed for an AASHTO HS 20 live load unless approved otherwise by the Bridge Design Engineer. Construction requirements, such as a year long expected use, and staging are sufficient reasons to justify designing for a higher live load of HL-93. Use of an HL-93 live load shall be approved by the Bridge Design Engineer.

### **2.3.6 Retaining Walls and Noise Walls**

The requirements for Preliminary Plans for retaining walls and noise walls are similar to the requirements for bridges. The plan and elevation views define the overall limits and the geometry of the wall. The section view will show general structural elements that are part of the wall and the surface finish of the wall face.

The most common types of walls are outlined in Section 9.4.2 of the *Bridge Design Manual* and Chapter 1130 of the *Design Manual*. The Bridge and Structures Office is responsible for Preliminary Plans for all nonstandard walls (retaining walls and noise walls) as spelled out in Chapter 1130 of the *Design Manual*.

### **2.3.7 Bridge Deck Drainage**

The HQ Hydraulics Office provides a review of the Preliminary Plan with respect to the requirements for bridge deck drainage. An 11x17 print shall be provided to the HQ Hydraulics Office for their review as soon as the Preliminary Plan has been developed. The length and width of the structure, profile grade, superelevation diagram, and any other pertinent information (such as locations of drainage off the structure) should be shown on the plan. For work with existing structures, the locations of any and all bridge drains shall be noted.

The HQ Hydraulics Office or the Region Hydraulics staff will determine the type of drains necessary (if any), the location, and spacing requirements. They will furnish any details or modifications required for special drains or special situations.

If low points of sag vertical curves or superelevation crossovers occur within the limits of the bridge, the region should be asked to revise their geometrics to place these features outside the limits of the bridge. If such revisions cannot be made, the HQ Hydraulics Office will provide details to handle drainage with bridge drains on the structure.

### **2.3.8 Bridge Deck Protective Systems**

The Preliminary Plan shall note in the lower left margin the type of deck protective system to be utilized on the bridge. The most commonly used systems are described in Section 5.7.4 of the *Bridge Design Manual*.

New construction will generally be System 1 (2 1/2 inch concrete top cover plus epoxy-coated rebars for the top mat). System 2 (MC overlay) and System 3 (HMA overlay) are to be used on new construction that require overlays and on widenings for major structures. The type of overlay to be used should be noted in the bridge site data submitted by the Region. The bridge condition report will indicate the preference of the Deck Systems Specialist in the Bridge and Structures Office.

### **2.3.9 Construction Clearances**

Most projects involve construction in and around traffic. Both traffic and construction must be accommodated. Construction clearances and working room must be reviewed at the preliminary plan stage to verify bridge constructability.

For construction clearances for roadways, the Region shall supply the necessary traffic staging information with the bridge site data. This includes temporary lane widths and shoulder or shy distances, allowable or necessary alignment shifts, and any special minimum vertical clearances. With this information, the designer can establish the falsework opening or construction opening.

The horizontal dimension of the falsework or construction opening shall be measured normal to the alignment of the road which the falsework spans. The horizontal dimension of the falsework or construction opening shall be the sum of the temporary traffic lane widths and shoulder or shy distances, plus two 2-foot widths for the temporary concrete barriers, plus additional 2 feet shy distances behind the temporary barriers. For multi-span falsework openings, a minimum of 2 feet, and preferably 4 feet, shall be used for the interior support width. This interior support shall also have 2 feet shy on both sides to the two 2-foot wide temporary concrete barriers that will flank the interior support.

The minimum vertical clearance of the construction opening shall normally be 14 feet 6 inches or as specified by the Region. The vertical space available for the falsework must be deep to accommodate the falsework stringers, camber strips, deck, and all deflections. If the necessary depth is greater than the space available, either the minimum vertical clearance for the falsework shall be reduced or the horizontal clearance and span for the falsework shall be reduced, or the profile grade of the structure shall be raised. Any of these alternatives shall be approved by the Region.

Once the construction clearances have been determined the designer should meet with the region to review the construction clearances to ensure compatibility with the construction staging. This review should take place prior to finalizing the preliminary bridge plan.

For railroads see BDM Section 2.3.2H.

### **2.3.10 Design Guides for Falsework Depth Requirements**

Where falsework is required to support construction of cast-in-place superstructure or segmental elements, the designer of the Preliminary Plan shall confirm with the Region the minimum construction opening. See BDM Section 2.3.9

The bridge designer shall consult with the Construction Support Engineer on falsework depth requirements outlined below.

Bridge designers shall evaluate falsework depth requirements based on the following guidelines:

#### **A. Falsework Spans < 36 feet and No Skews**

No design is necessary. Provide for minimum vertical clearance and a minimum falsework depth of 4 feet to accommodate:

W36X\_\_\_ steel beam sections

3/4-inch camber strip

5/8-inch plywood

4x4 joists

6-inch depth for segmental falsework release

B. Falsework Spans > 36 feet or Spans with Skews or Limited Falsework Depth

While the falsework or construction openings are measured normal to the alignment which the falsework spans, the falsework span is measured parallel to the bridge alignment.

The Preliminary Plan designer shall perform preliminary design of the falsework sufficiently to determine its geometric and structural feasibility. Shallow, heavy, close-spaced wide-flange steel beams may be required to meet the span requirements within the available depth. The preliminary design shall be based on design guides in the Standard Specifications 6-02.3(17). Beams shall be designed parallel to the longitudinal axis of the bridge. The falsework span deflection shall be limited according to the Standard Specifications 6-02.3(17)B: generally span/360 for a single concrete placement, such as a slab, and span/500 for successive concrete placement forming a composite structure. This limits the stresses in the new structure from the construction and concrete placement sequences. Beam sizes shall be shown in the final plans (and in the Preliminary Plans as required) with the Contractor having the option of submitting an alternate design. The designer shall verify availability of the beam sizes shown in the plans.

C. Bridge Widening

For bridge widenings where the available depth for the falsework is fixed, designers shall design falsework using shallower and heavier steel beams to fit within the available depth. Beam sizes and details shall be shown in the final plans (and in the Preliminary Plans as required) with the Contractor having the option of using an alternate design. The designer shall verify availability of the beam sizes shown in the plans.

In some cases it may be appropriate to consider a shallower superstructure widening, but with similar stiffness, in order to accommodate the falsework and vertical clearance.

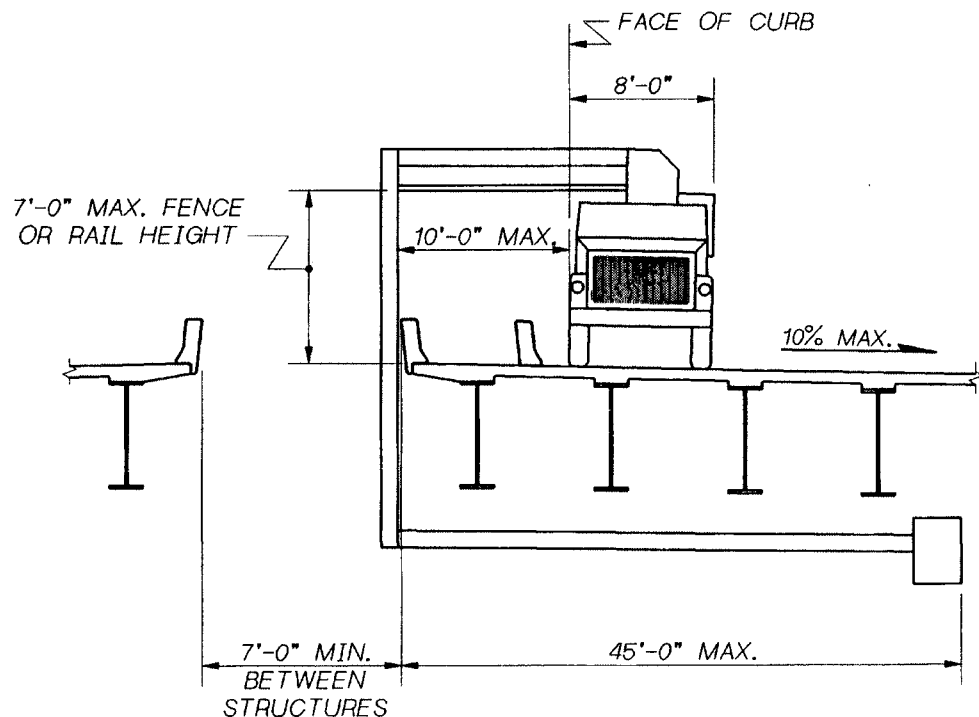
D. Bridge with Skews

Falsework beams shall be laid out and designed for spans parallel to the bridge centerline or perpendicular to the main axis of bending. The centerline of falsework beams shall be located within 2 feet of the bridge girder stems and preferably directly under the stems or webs in accordance with Standard Specification Section 6-02.3(17)E. Falsework beams placed normal to the skew or splayed complicate camber calculations and shall be avoided.

### **2.3.11 Inspection and Maintenance Access**

A. General

FHWA mandates that bridges be inspected every two years. The BPO inspectors are required to access bridge components to within 3 feet for visual inspection and to access bearings close enough to measure movement. Maintenance personnel need to access damaged members and locations that may collect debris. This is accomplished by using many methods. Safety cables, ladders, bucket trucks, Under Bridge Inspection Truck (UBIT), (see Figure 2-6), and under bridge travelers are just a few of the most common methods. Preliminary Plan designers need to be aware of these requirements and prepare designs that allow access for bridge inspectors and maintenance personnel throughout the Preliminary Plan and TS&L planning phases.



**Limits of Under Bridge Inspection Truck  
Units Can Only Deploy to the Tight Side of Truck**

*Figure 2-6*

**B. Safety Cables**

Safety cables strung on steel plate girders or trusses allow for walking access. Care must be given to the application and location. Built-up plate girder bridges are detailed with a safety cable for inspectors walking the bottom flange. However, when the girders become more than 8 feet deep, the inspection of the top flange and top lateral connections becomes difficult to access. It is not feasible for the inspectors to stand on the bottom flanges when the girders are less than 5 feet deep. On large trusses, large gusset plates (3 feet or more wide) are difficult to circumvent. Tie-off cables are best located on the interior side of the exterior girder of the bridge except at large gusset plates. At these locations, cables or lanyard anchors should be placed on the inside face of the truss so inspectors can utilize bottom lateral gusset plates to stand on while traversing around the main truss gusset plates.

**C. Travelers**

Under bridge travelers, placed on rails that remain permanently on the bridge, can be considered on large steel structures. This is an expensive option, but it should be evaluated for large bridges with high ADT because access to the bridge would be limited by traffic windows that specify when a lane can be closed. Some bridges are restricted to weekend UBIT inspection for this reason.

**D. Abutment Slopes**

Slopes in front of abutments shall provide enough overhead clearance to the bottom of the superstructure to access bearings for inspection and possible replacement (usually 3 feet minimum).

## 2.4 Selection of Structure Type

### 2.4.1 Bridge Types

See Appendix sheet 2.4-A1 for a bar graph comparing structure type, span range and cost range.

The required superstructure depth is determined during the preliminary plan development process. The AASHTO LRFD Specifications in BDM Section 2.5.2.6.3 show traditional minimum depths for constant depth superstructures. WSDOT has developed superstructure depth-to-span ratios based on past experience.

The superstructure depth is used to establish the vertical clearance that is available below the superstructure. For preliminary plans, the designer should use the more conservative depth determined from either the AASHTO LRFD criteria or the WSDOT criteria outlined below. In either case, the minimum depth includes the deck thickness. For both simple and continuous spans, the span length is the horizontal distance between centerlines of bearings.

The superstructure depth may be refined during the final design phase. It is assumed that any refinement will result in a reduced superstructure depth so the vertical clearance is not reduced from that shown in the preliminary plan. However, when profile grade limitations restrict superstructure depth, the preliminary plan designer shall investigate and/or work with the structural designer to determine a superstructure type and depth that will fit the requirements.

#### A. Reinforced Concrete Slab

##### 1. Application

Used for simple and continuous spans up to 60 feet.

##### 2. Characteristics

Design details and falsework relatively simple. Shortest construction time for any cast-in-place structure. Correction for anticipated falsework settlement must be included in the dead load camber curve because of the single concrete placement sequence.

##### 3. Depth/Span Ratios

###### a. Constant depth

Simple span	$1/22$
-------------	--------

Continuous spans	$1/25$
------------------	--------

###### b. Variable depth

Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

#### B. Reinforced Concrete Tee-Beam

##### 1. Application

Used for continuous spans 30 feet to 60 feet. Has been used for longer spans with inclined leg piers.

##### 2. Characteristics

Forming and falsework is more complicated than for a concrete slab. Construction time is longer than for a concrete slab.

3. Depth/Span Ratios

a. Constant depth

Simple spans  $1/13$

Continuous spans  $1/15$

b. Variable depth

Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

C. Reinforced Concrete Box Girder

1. Application

Used for continuous spans 50 feet to 130 feet. Maximum simple span 110 feet to limit excessive dead load deflections.

2. Characteristics

Forming and falsework is somewhat complicated. Construction time is approximately the same as for a tee-beam. High torsional resistance makes it desirable for curved alignments.

3. Depth/Span Ratios\*

a. Constant depth

Simple spans  $1/18$

Continuous spans  $1/20$

b. Variable depth

Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

\*If the configuration of the exterior web is sloped and curved, a larger depth/span ratio may be necessary.

D. Post-Tensioned Concrete Box Girder

1. Application

Normally used for continuous spans longer than 130 feet or simple spans longer than 110 feet. Should be considered for shorter spans if a shallower structure depth is needed.

2. Characteristics

Construction time is somewhat longer due to post-tensioning operations. High torsional resistance makes it desirable for curved alignments.

3. Depth/Span Ratios\*

a. Constant depth

Simple spans  $1/20.5$

Continuous spans  $1/25$



b. Variable depth

Two span structures

At Center of span  $1/25$

At Intermediate pier  $1/12.5$

Multi-span structures

At Center of span  $1/36$

At Intermediate pier  $1/18$

\*If the configuration of the exterior web is sloped and curved, a larger depth/span ratio may be necessary.

E. Prestressed Concrete Sections

1. Application

Local precast fabricators have several standard forms available for precast concrete sections based on the WSDOT standard girder series. These are versatile enough to cover a wide variety of span lengths.

WSDOT standard girders are:

- a. W95G, W83G, WF74G, WF58G, WF50G, WF42G, W74G, W58G, W50G, and W42G precast, prestressed concrete I-girders requiring a cast-in-place concrete roadway deck used for spans less than 180 feet. The number (eq. 95) specifies the girder depth in inches.

W95PTG, W83PTG and WF74PTG post-tensioned, precast segmental I-girders with cast-in-place concrete roadway deck use for simple span up to 225 ft. and continuous span up to 250 ft.

- b. U\*\*G\* and UF\*\*G\* precast, prestressed concrete tub girders requiring a cast-in-place concrete roadway deck are used for spans less than 140 ft. “U” specifies webs without flanges, “UF” specifies webs with flanges, \*\* specifies the girder depth in inches, and \* specifies the bottom flange width in feet. U\*\*G\* girders have been precast as shallow as 26 inches.

Post-tensioned, precast, prestressed tub girders with cast-in-place concrete roadway deck are used for simple span up to 200 ft. and continuous span up to 250 ft.

- c. W65DG, W53DG, W41DG, and W35DG precast, prestressed concrete decked bulb tee girders requiring an ACP overlay roadway surface used for span less than 150 ft.
- d. W62BTG, W50BTG, W38BT6, and W32BTG precast, prestressed concrete bulb tee girders requiring a cast-in-place concrete deck for simple spans up to \_\_\_\_ feet.
- e. W74TFG, W62TF6, W50TF6, W38TF6, and W32TFG precast, prestressed concrete thin flange deck bulb tee girders requiring a cast-in-place concrete deck for simple spans up to \_\_\_\_ feet.
- f. 12-inch, 18-inch, and 26-inch precast, prestressed slabs requiring an HMA overlay roadway surface used for spans less than 80 ft.
- g. 26-inch precast, prestressed ribbed girder, deck double tee, and double tee members requiring an HMA overlay roadway surface used for span less than 40 ft.

2. Characteristics

Superstructure design is quick for pretensioned girders with proven user-friendly software (PGSuper and QConBridge)

Construction details and forming are fairly simple. Construction time is less than for a cast-in-place bridge. Little or no falsework is required. Falsework over traffic is usually not required; construction time over existing traffic is reduced.

Precast girders usually require that the bridge roadway superelevation transitions begin and end at or near piers; location of piers should consider this. The Region may be requested to adjust these transition points if possible.

Fully reinforced, composite 8 inch cast-in-place deck slabs continuous over interior piers or reinforced 5 inch cast-in-place deck slabs continuous over interior piers have been used with f. and g.

F. Composite Steel Plate Girder

1. Application

Used for simple spans up to 260 feet and for continuous spans from 120 to 400 feet. Relatively low dead load when compared to a concrete superstructure makes this bridge type an asset in areas where foundation materials are poor.

2. Characteristics

Construction details and forming are fairly simple Construction time is comparatively short. Shipping and erecting of large sections must be reviewed. Cost of maintenance is higher than for concrete bridges. Current cost information should be considered because of changing steel market conditions.

3. Depth/Span Ratios

a. Constant depth

Simple spans	$1/22$
--------------	--------

Continuous spans	$1/25$
------------------	--------

b. Variable depth

@ Center of span	$1/40$
------------------	--------

@ Intermediate pier	$1/20$
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G. Composite Steel Box Girder

1. Use

Used for simple spans up to 260 feet and for continuous spans from 120 to 400 feet. Relatively low dead load when compared to a concrete superstructure makes this bridge type an asset in areas where foundation materials are poor.

2. Characteristics

Construction details and forming are more difficult than for a steel plate girder. Shipping and erecting of large sections must be reviewed. Current cost information should be considered because of changing steel market conditions.

### 3. Depth/Span Ratios

#### a. Constant depth

Simple spans  $1/22$

Continuous spans  $1/25$

#### b. Variable depth

At Center of span  $1/40$

At Intermediate pier  $1/20$

**Note:** Sloping webs are not used on box girders of variable depth.

## H. Steel Truss

### 1. Application

Used for simple spans up to 300 feet and for continuous spans up to 1,200 feet. Used where vertical clearance requirements dictate a shallow superstructure and long spans or where terrain dictates long spans and construction by cantilever method.

### 2. Characteristics

Construction details are numerous and can be complex. Cantilever construction method can facilitate construction over inaccessible areas. Through trusses are discouraged because of the resulting restricted horizontal and vertical clearances for the roadway.

### 3. Depth/Span Ratios

a. Simple spans  $1/6$

#### b. Continuous spans

@ Center of span  $1/18$

@ Intermediate pier  $1/9$

## I. Segmental Concrete Box Girder

### 1. Application

Used for continuous spans from 200 to 700 feet. Used where site dictates long spans and construction by cantilever method.

### 2. Characteristics

Use of travelers for the form apparatus facilitates the cantilever construction method enabling long-span construction without falsework. Precast concrete segments may be used. Tight geometric control is required during construction to ensure proper alignment.

### 3. Depth/Span Ratios

#### Variable depth

At Center of span  $1/50$

At Intermediate pier  $1/20$

## J. Railroad Bridges

### 1. Use

For railway over highway grade separations, most railroad companies prefer simple span steel construction. This is to simplify repair and reconstruction in the event of derailment or some other damage to the structure.

### 2. Characteristics

The heavier loads of the railroad live load require deeper and stiffer members than for highway bridges. Through girders can be used to reduce overall structure depth if the railroad concurs. Piers should be normal to the railroad to eliminate skew loading effects.

### 3. Depth/Span Ratios

Constant depth

Simple spans	$1/12$
--------------	--------

Continuous two span	$1/14$
---------------------	--------

Continuous multi-span	$1/15$
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## K. Timber

### 1. Use

Generally used for spans under 40 feet. Usually used for detour bridges and other temporary structures.

### 2. Characteristics

Excellent for short-term duration as for a detour. Simple design and details.

### 3. Depth/Span Ratios

Constant depth

Simple span – Timber beam	$1/10$
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Simple span – Glulam beam	$1/12$
---------------------------	--------

Continuous spans	$1/14$
------------------	--------

## L. Other

Bridge types such as cable-stayed, suspension, arch, tied arch, and floating bridges have special and limited applications. The use of these bridge types is generally dictated by site conditions. Preliminary design studies will generally be done when these types of structures are considered.

## 2.4.2 Wall Types

Retaining walls, wingwalls, curtain walls, and tall closed abutment walls may be used where required to shorten spans or superstructure length or to reduce the width of approach fills. The process of selecting a type of retaining wall should economically satisfy structural, functional, and aesthetic requirements and other considerations relevant to a specific site. A detailed listing of the common wall types and their characteristics can be found in Chapter 8 of the *Bridge Design Manual*.

## **2.5 Aesthetic Considerations**

### **2.5.1 General Visual Impact**

A bridge has a strong visual impact in any landscape. Steps must be taken to assure that even the most basic structure will complement rather than detract from its surroundings. The EIS and bridge site data submitted by the Region should each contain a discussion on the aesthetic importance of the project site. This commentary, together with submitted video and photographs, will help the designer determine the appropriate structure type.

The State Bridge and Structures Architect should be contacted early in the preliminary bridge plan process for input on aesthetics. Normally, a visit to the bridge site with the State Bridge and Structures Architect and Region design personnel should be made.

Aesthetics is a very subjective element that must be factored into the design process in the otherwise very quantitative field of structural engineering. Bridges that are well proportioned structurally using the least material possible are generally well proportioned. However, the details such as pier walls, columns, and crossbeams require special attention to ensure a structure that will enhance the general vicinity.

For large projects incorporating several to many bridges and retaining walls, an architectural theme is frequently developed to bring consistency in structure type, details, and architectural appointments. The preliminary plan designer shall work with the State Bridge and Structures Architect to implement the theme.

### **2.5.2 End Piers**

#### **A. Wingwalls**

The size and exposure of the wingwall at the end pier should balance, visually, with the depth and type of superstructure used. For example, a prestressed girder structure fits best visually with a 15-foot wingwall (or curtain wall/retaining wall). However, there are instances where a 20-foot wingwall (or curtain wall/retaining wall) may be used with a prestressed girder (maximizing a span in a remote area, for example or with deep girders where they are proportionally better in appearance). The use of a 20-foot wingwall shall be approved by the Bridge Design Engineer and the State Bridge and Structures Architect.

It is less expensive for bridges of greater than 40 feet of overall width to be designed with wingwalls (or curtain wall/retaining wall) than to use a longer superstructure.

#### **B. Retaining Walls**

For structures at sites where profile, right of way, and alignment dictate the use of high exposed wall-type abutments for the end piers, retaining walls that flank the approach roadway can be used to retain the roadway fill and reduce the overall structure length. Stepped walls are often used to break up the height, and allow for landscape planting. A curtain wall runs between the bridge abutment and the heel of the abutment footing. In this way, the joint in the retaining wall stem can coincide with the joint between the abutment footing and the retaining wall footing. This simplifies design and provides a convenient breaking point between design responsibilities if the retaining walls happen to be the responsibility of the Region. The length shown for the curtain wall dimension is an estimated dimension based on experience and preliminary foundation assumptions. It can be revised under design to satisfy the intent of having the wall joint coincide with the end of the abutment footing.

C. Slope Protection

The Region is responsible for making initial recommendations regarding slope protection. It should be compatible with the site and should match what has been used at other bridges in the vicinity. The type selected shall be shown on the Preliminary Plan. It shall be noted on the “Not Included in Bridge Quantities” list.

**2.5.3 Intermediate Piers**

The size, shape, and spacing of the intermediate pier elements must satisfy two criteria. They must be correctly sized and detailed to efficiently handle the structural loads required by the design and shaped to enhance the aesthetics of the structure.

The primary view of the pier must be considered. For structures that cross over another roadway, the primary view will be a section normal to the roadway. This may not always be the same view as shown on the Preliminary Plan as with a skewed structure, for example. This primary view should be the focus of the aesthetic review.

Tapers and flares on columns should be kept simple and structurally functional. Fabrication and constructability of the formwork of the pier must be kept in mind. Crossbeam ends should be carefully reviewed. Skewed bridges and bridges with steep profile grades or those in sharp vertical curves will require special attention to detail.

Column spacing should not be so small as to create a cluttered look. Column spacing should be proportioned to maintain a reasonable crossbeam span balance.

**2.5.4 Barrier and Wall Surface Treatments**

A. Plain Surface Finish

This finish will normally be used on structures that do not have a high degree of visibility or where existing conditions warrant. A bridge in a remote area or a bridge among several existing bridges all having a plain finish would be examples.

B. Fractured Fin Finish

This finish is the most common and an easy way to add a decorative texture to a structure. Variations on this type of finish can be used for special cases. The specific areas to receive this finish should be reviewed with the State Bridge and Structures Architect.

C. Pigmented Sealer

The use of a pigmented sealer can also be an aesthetic enhancement. The particular hue can be selected to blend with the surrounding terrain. Most commonly, this would be considered in urban areas. The selection should be reviewed with the Bridge Architect and the Region.

D. Architectural Details

Rustication grooves, relief panels, pilasters, and decorative finishes may visually improve appearance at transitions between different structure types such as cast-in-place abutments to structural earth retaining walls. Contact the State Bridge and Structures Architect for guidance.

### **2.5.5 Superstructure**

The horizontal elements of the bridge are perhaps the strongest features. The sizing of the structure depth based on the span/depth ratios in BDM Section 2.4.1, will generally produce a balanced relationship.

Haunches or rounding of girders at the piers can enhance the structure's appearance. The use of such features should be kept within reason considering fabrication of materials and construction of formwork. The amount of haunch should be carefully reviewed for overall balance from the primary viewing perspective. Haunches are not limited to cast-in-place superstructures, but may be used in special cases on precast, prestressed I girders. They require job-specific forms which increase cost, and standard design software is not directly applicable.

The slab overhang dimension should approach that used for the structure depth. This dimension should be balanced between what looks good for aesthetics and what is possible with a reasonable slab thickness and reinforcement.

For box girders, the exterior webs can be sloped, but vertical webs are preferred. The amount of slope should not exceed  $1\frac{1}{2}:1$  for structural reasons, and should be limited to 4:1 if sloped webs are desired. Sloped webs should only be used in locations of high aesthetic impact.



## **2.6 Miscellaneous**

### **2.6.1 Structure Costs**

See BDM Section 12.3 for preparing cost estimates for preliminary bridge design.

### **2.6.2 Handling and Shipping Precast Members and Steel Beams**

Bridges utilizing precast concrete beams or steel beams need to have their access routes checked and sites reviewed to be certain that the beams can be transported to the site. It must also be determined that they can be erected once they reach the site.

Both the size and the weight of the beams must be checked. Likely routes to the site must be adequate to handle the truck and trailer hauling the beams. Avoid narrow roads with sharp turns, steep grades, and/or load-rated bridges, which may prevent the beams from reaching the site. The Bridge Preservation Office should be consulted for limitations on hauling lengths and weights.

Generally 200 kips is the maximum weight of a girder that may be hauled by truck. When the weight of a prestressed concrete girder cast in one piece exceeds 160 kips, it may be required to include a post-tensioned 2-piece option detailed in the contract plans.

The site should be reviewed for adequate space for the contractor to set up the cranes and equipment necessary to pick up and place the girders. The reach and boom angle should be checked and should accommodate standard cranes.

### **2.6.3 Salvage of Materials**

When a bridge is being replaced or widened, the material being removed should be reviewed for anything that WSDOT may want to salvage. Items such as aluminum rail, luminaire poles, sign structures, and steel beams should be identified for possible salvage. The Region should be asked if such items are to be salvaged since they will be responsible for storage and inventory of these items.

## **2.7 WSDOT Standard Highway Bridge**

### **2.7.1 Design Elements**

The following are standard design elements for bridges carrying highway traffic. They are meant to provide a generic base for consistent, clean looking bridges, and to reduce design and construction costs. Modification of some elements may be required, depending on site conditions. This should be determined on a case-by-case basis during the preliminary plan stage of the design process.

#### **A. General**

Fractured Fin Finish shall be used on the exterior face of the traffic barrier. All other surfaces shall be Plain Surface Finish.

Exposed faces of wingwalls, columns, and abutments shall be vertical. The exterior face of the traffic barrier and the end of the intermediate pier crossbeam and diaphragm shall have a 1:12 backslope.

#### **B. Substructure**

End piers use the following details:

15 ft wingwalls with prestressed girders up to 74 inches in depth or a combination of curtain wall/retaining walls.

Stub abutment wall with vertical face. Footing elevation, pile type (if required), and setback dimension are determined from recommendations in the Materials Laboratory Geotechnical Services Branch Geotechnical Report.

Intermediate piers use the following details:

“Semi-raised” Crossbeams: The crossbeam below the girders is designed for the girder and slab dead load, and construction loads. The crossbeam and the diaphragm together are designed for all live loads and composite dead loads. The minimum depth of the crossbeam shall be 3 feet.

“Raised” Crossbeams: The crossbeam is at the same level as the girders are designed for all dead and live loads. “Raised” crossbeams are only used in conjunction with Prestressed Concrete Tub Girders.

Round Columns: Columns shall be 3 feet or 4 feet in diameter. Dimensions are constant full height with no tapers. Bridges with roadway widths of 40 feet or less will generally be single column piers. Bridges with roadway widths of greater the 40 feet shall have two or more columns, following the criteria established in BDM Section 2.3.1 H.

#### **C. Superstructure**

Concrete Slab: 7-inch minimum thickness, with the top mat being epoxy coated steel reinforcing bars.

Prestressed Girders: Girder spacing will vary depending on roadway width and span length. The slab overhang dimension is approximately half of the girder spacing. Girder spacing typically ranges between 6 feet and 12 feet.

W95G	Spans up to about 170 feet
W83G	Spans up to about 180 feet
WF74G	Spans up to about 155 feet
WF74G	Spans up to about 145 feet
W58G	Spans up to about 120 feet
W50	Spans up to about 100 feet
W42	Spans up to about 80 feet

Intermediate Diaphragms: Locate at the midspan for girders up to 80 feet long. Locate at third points for girders between 80 feet and 150 feet long and at quarter points for spans over 150 feet.

End Diaphragms: "End Wall on Girder" type.

Traffic Barrier: "F-shape" or Single-sloped barrier.

Fixed Diaphragm at Inter. Piers: Full width of crossbeam between girders and outside of the exterior girders.

Hinged Diaphragm at Inter. Piers: Partial width of crossbeam between girders. Sloped curtain panel full width of crossbeam outside of exterior girders, fixed to ends of crossbeam.

BP Rail: 3 feet 6 inches overall height for pedestrian traffic. 4 feet 6 inches overall height for bicycle traffic.

Sidewalk: 6-inch height at curb line. Transverse slope of -0.01 feet per foot towards the curb line.

Sidewalk barrier: Inside face is vertical. Outside face slopes 1:12 outward.

#### D. Examples

Appendices 2.7-A1 and A2 detail the standard design elements of a standard highway bridge.

The following bridges are good examples of a standard highway bridge. However, they do have some modifications to the standard.

SR 17 Undercrossing 395/110

Contract 3785

Mullenix Road Overcrossing 16/203E&W

Contract 4143

### 2.7.2 Detailing the Preliminary Plan

The Bridge Preliminary Plan is used and reviewed by the Bridge and Structures Office or consultant who will do the structural design, Region designers and managers, Geotechnical engineers, Hydraulics engineers, Program managers, FHWA engineers and local agency designers and managers. It sometimes is used in public presentation of projects. With such visibility it is important that it's detailing is clear, complete, professional, and attractive. The designer, detailer, and checker shall strive for completeness and consistency in information, layout, line style, and fonts. Appendix B contains examples of Preliminary Plans following time-proven format that may be helpful. See also Chapter 11, Detailing Practice.

Typical sheet layout is as follows:

1. Plan and Elevation views. (This sheet ultimately becomes the Layout sheet of the design plan set)

2. Typical Section including details of stage construction.

Superelevation diagrams, tables of existing elevations, Notes to Region, and other miscellaneous details as required shall go on Sheet 2, 3, or 4, as many as are required. See also the Preliminary Plan Checklist for details, dimensions, and notes typically required. The completed plan sheets shall be reviewed for consistency by the Preliminary Plans Detailing Specialist.

## **2.99 Bibliography**

1. Federal Highway Administration (FHWA) publication *Federal Aid Highway Program Manual*.  
  
FHWA Order 5520.1 (dated December 24, 1990) contains the criteria pertaining to Type, Size, and Location studies.  
  
Volume 6, Chapter 6, Section 2, Subsection 1, Attachment 1 (Transmittal 425) contains the criteria pertaining to railroad undercrossings and overcrossings.
2. Washington Utilities and Transportation Commission *Clearance Rules and Regulations Governing Common Carrier Railroads*.
3. American Railway Engineering and Maintenance Association (AREMA) *Manual for Railroad Engineering*. Note: This manual is used as the basic design and geometric criteria by all railroads. Use these criteria unless superseded by FHWA or WSDOT criteria.
4. Washington State Department of Transportation (WSDOT) *Design Manual* (M 22-01).
5. *Local Agency Guidelines* (M 36-63).
6. American Association of State Highway and Transportation Officials *AASHTO LRFD Bridge Design Specification*.
7. The Union Pacific Railroad “*Guidelines for Design of Highway Separation Structures over Railroad (Overhead Grade Separation)*”